REAL-TIME FILTERING OF TRANSIENT VISUAL EVOKED POTENTIALS

T.F. COLLURA and R.J. LORIG, Case Western Reserve University
Department of Biomedical Engineering, Cleveland, Ohio

When repetitive flashes of light are delivered to the eye at rates below 8 per second, the resulting periodic evoked potential can be understood as the superposition of successive transient responses. The response is periodic due to the stimulus, and therefore possesses energy centered at integer multiples of the flash frequency in a Fourier Series.

The response is also time-varying, due to changes in mental state and eye position, producing sidebands as modulation products. The evoked potential can therefore be measured by narrowband filtering the raw EEG with a comb filter passing the proper frequencies. Because of the filter selectivity, most background EEG activity is rejected and a signal-to-noise improvement is possible. This principle leads to a real-time method of computing average evoked responses.

A system was constructed to control the flashing of the strobe, and filter the EEG at the flashing frequency and its 1st, 2nd, and 3rd harmonic. In order to ensure that frequencies were exact multiples, reference sinewaves were generated digitally and used to set the center frequencies of modulating filters as shown in figure 1. The filter transfer function is identical to that of an RLC filter. Figure 2 shows the experimental setup.

When the strobe was flashed on a subject's eyelids, the evoked potential could be measured at the filter output. Short-term changes in amplitude and waveshape were observed. Preliminary experiments show that these fluctuations depend on movement of the eye and eyelid, intensity of the flashes, and mental state as indicated by flash counting (attention), conversation (distraction), and mental arithmetic (problem solving) among other factors.

To test the accuracy of the technique, conventional averages were computed from the raw EEG records and superimposed on typical filtered responses from the same epoch. In all subjects, filtered response followed the shape and amplitude of the averaged response, to the limits of the 4-frequency estimate. Inclusion of higher harmonics would improve the fit. Figure 3 shows this, when the flash rate was 4 per second and 64 responses were averaged.

With this technique, it is possible to study short term variation in noise-free evoked potentials without the delay normally required for averaging. This should be especially useful in studies of short-term memory, attention, and other transient brain processes.

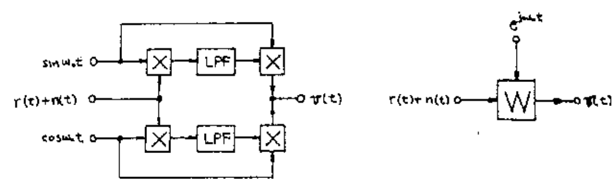

Figure 1. Modulating filter (left) and equivalent block symbol (right).

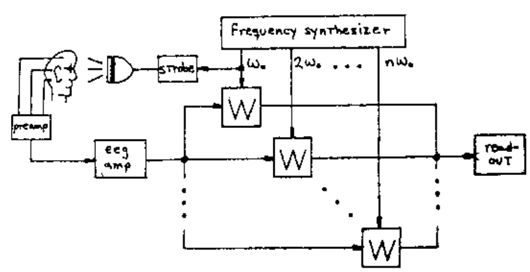

Figure 2. System for comb-filtering evoked potentials

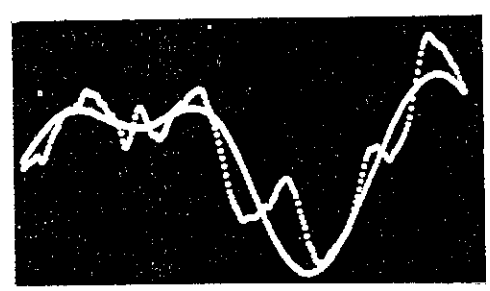

Figure 3. 200-msec AVEP superimposed on comb-filtered VEP for 4 flashes/second.

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Department of Biomedical Engineering
Case Western Reserve University
Cleveland, Ohio 44106